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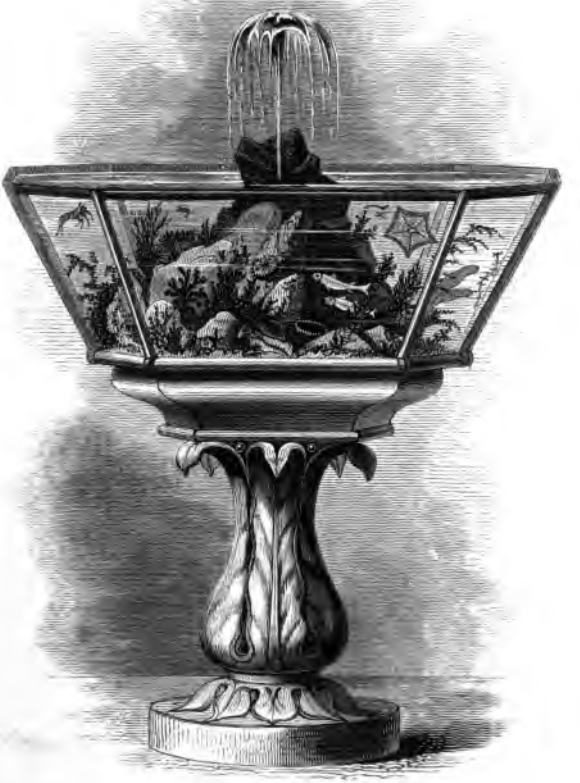
A HANDBOOK TO THE MARINE AQUARIUM

GOSSE



A HANDBOOK

TO THE

MARINE AQUARIUM:

CONTAINING

PRACTICAL INSTRUCTIONS FOR
CONSTRUCTING, STOCKING, AND MAINTAINING A TANK,
AND FOR COLLECTING PLANTS AND ANIMALS.

BY

PHILIP HENRY GOSSE, A.L.S.

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MDCCCLV.

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PREFACE.

THE increasing popularity of the Marine Aquarium demands a Handbook of Practical Instructions for establishing and maintaining it, and I am probably the most proper person to write such a book. Perhaps it might have been sufficient to refer inquirers to my volume on the subject; but the price of that work, arising mainly from the costliness of its illustrations, puts it beyond the power of many persons, who yet desire to keep marine animals. The main portion of that volume is, moreover, occupied with the habits and manners of the tenants in an Aquarium.

The concluding chapter of that work has formed the ground of the present Handbook. The whole,

however, has been re-written, and copious additions have been made, bringing it up to the present state of our experience. The price at which it is issued will, it is hoped, bring it within the reach of all.

P. H. G.

LONDON,
October, 1855.

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HANDBOOK

OF

THE MARINE AQUARIUM.

AN Aquarium is simply a vessel of water in which aquatic plants, or animals, or both, are preserved alive; and a Marine Aquarium is, of course, such a vessel, whose contents, animate and inanimate, are derived from the sea.

In general it is the marine animals that form the main source of interest, everything else being merely accessory to these. Many of the sea-plants, "weeds" though they are called, are indeed very beautiful; the elegant forms of some, the delicate muslin-like tracery of others, the plumose lightness of more, "fine as silkworm's thread," and the beautiful play of colours, red and green, which a well-stocked Aquarium displays, as the light is transmitted through their pellucid substance, may claim for these objects more than an indirect attention. Still it is true, that, in most cases, they are preserved because they cannot be dispensed with.

If we attempt to collect and to keep marine

animals alone in sea-water, however pure it may have been at first, it speedily becomes offensively fetid, the creatures look sickly, and rapidly die off, and we are glad to throw away the whole mass of corruption.

Why is this? why should they die in our vessels when they live so healthily in the little pools and basins of the rock, that are no larger? For the very same reason that we should quickly die in a room perfectly air-tight. The blood of all animals requires to be perpetually renewed by the addition to it of the element called oxygen; and when it cannot obtain this it becomes unfit for the support of life. Terrestrial animals obtain this gaseous element from the air; aquatic animals (that is, those which are strictly such) obtain it from the water. But in either case it is principally produced by *living plants while under the action of light.* If, then, we can furnish our captives with a perpetual manufactory of oxygen, the main cause of their sudden death is removed. Of course they have other requirements, but this is the most urgent, the indispensable.

In a state of nature, the rocks, the crannies, the pools, the sea-bottom are studded with various living plants, which we call sea-weeds; and these, under the daily stimulus of sunlight, direct or indirect, produce and throw off a vast quantity of oxygen, which, by the action of the waves and currents, is diffused through all parts of the habitable sea, and maintains the health of its countless swarms of animals.

In an Aquarium we seek to imitate this chemistry of nature. We collect the plants as well as the animals; and, a little observation teaching us how

to proportion the one to the other, we succeed in maintaining, on a small scale, the balance of animal and vegetable life. Other less important benefits result from this arrangement; the creatures love retirement and shelter, and this they find in the umbrageous fronds; they delight to roam and to play and to rest in the feathery tufts, and not a few find their favourite food in the delicate leaves of the submerged herbs.

On the other hand, the plant is indebted to the animal for some of its supplies. The carbon, with which its solid parts are built up, is derived from the carbonic acid which is thrown off by animals in the process of breathing; a poisonous gas which would soon vitiate the water were it not taken up and appropriated by the plants.

Such, then, is the principle on which the Aquarium is founded; and any conditions under which it can be carried out will serve, provided of course they be suitable in other respects to the habits of the animals and our purpose in keeping them. I now proceed to other details on the practical management, so far as I am able, from my own experience, and that of not a few of my friends, to give them; premising that I have at present (September, 1855) at my residence at Islington, one marine tank full of animals and plants in the highest condition, the water in which, though as clear as crystal and quite colourless, has never been even removed from the vessel since it was first put in, nineteen months ago. I have, also, other tanks and vases, which are respectively seventeen, fourteen, thirteen, and four months old. The successful establishment of these has not been achieved without some failures and losses, which

yet must not be considered as unmitigated misfortunes, since they have added to my experience, and better fitted me to understand and sympathize with the difficulties of other beginners.

THE TANK.

FORM, SIZE, AND MATERIALS.—So much depends on individual taste and means in this respect, as well as on the situation which the Aquarium is intended to occupy, that no rule can be laid down for dimensions. My largest tank (now in use as a *fresh* water Aquarium), is a parallel-sided vessel, two feet long, one and a half foot wide, one and a half foot deep; the sides and ends of plate glass, three-sixteenths thick; the bottom, a slab of slate one inch thick; the corners of birch-wood, turned into pillars, each surmounted by a knob, and united by a frame-top or bar going all round. The glass is set in grooves in the slate and wood, and fastened with white-lead putty. I have two others agreeing with this in all respects, except in dimensions, the smallest being (in the clear) fifteen inches long, twelve inches wide, and twelve inches deep. This is a very neat and pretty object for a parlour table, and will hold at least fifty animals appreciable to the senses, provided they be well selected, and a sufficient growth of plants established.

I have also another tank with a sloping back, made on Mr. Warington's plan. It is of zinc, with the back and two sides of slate, the front and two front-sides alone being of glass. Its form is six-sided, the front resembling a bow-

window; it is three feet long by one foot ten inches in greatest width, and the same in depth; the peculiarity is that the back slopes inward, so that the bottom is but eight inches wide. I cannot commend this form; its appearance is lumbering and inelegant; the opacity of the back and sides throws the interior into a degree of darkness, (even though placed in a south window,) which greatly impedes observation; and I cannot see, by comparison with my others, which are of glass all round, that the advantage anticipated, of admitting the light only from above, is real, or at least of sufficient importance to compensate the uninviting gloominess alluded to. Its depth also is too great; a foot of water is as much as is needful for a parlour Aquarium.

A novel mode of constructing tanks has been suggested to me by Mr. W. Dodgson of Wigton, Cumberland, which, as I have not tried it, I will describe in his own words.

"I have lately been constructing two Aquariums, and as the way in which they are made may be new and perhaps useful to you, I take the liberty of communicating it. Slate we have no opportunity of procuring in suitable pieces for joining, and our stone is too porous for the purpose. I therefore got the bottom and two ends made in one piece out of the yellow clay used for garden vases, chimney-tops, and other coarse pottery, and found it answered exceedingly well and has several advantages.

"Partly as a means of supporting the ends, but principally to form artificial rockwork and shelter for the animals, the two ends are buttressed inside with very rough pieces of clay, put on so as to leave

plenty of holes and fissures; the fire fastens these firmly together and makes them as hard as stone. Grooves are left along the bottom, and up the two ends, for the glass to fit into. The outside is relieved with ornamental work. Cheapness is a great recommendation; the pot being charged 1*d.* or 2*d.* per hundred cubical inches, according to the amount of ornament. I should think your London potters would make something very neat, and the mould once made, they could be supplied very cheaply; and considering their freedom from leakage and their strength, I think they would prove as satisfactory as any kind of cistern. Mine are about three feet long, and thirty inches high and broad, holding thirty gallons each. I bed the glass with white lead, leaving about a quarter inch in depth of the groove unfilled. When the putty is set, I fill it up with shell-lac dissolved in naphtha and made into a paste with whiting. This sets very quickly; and, hard as stone, is quite insoluble, and prevents the water from coming in contact with the lead, which I think must constantly be giving off small quantities of oxide."

In reply to some inquiries of mine, the same gentleman writes me further as follows:—

"I have delayed replying to you respecting the price of pottery for Aquariums till I had an opportunity of seeing the party who made mine. The price of one such as you name would be 6*s.* or 8*s.*, but, as it would weigh four hundredweight, the carriage to London would be quite as much. He was rather doubtful whether with his coarse clay he could make one the length you name to hold together; as two or three of mine, which were shorter, separated in the middle when being burnt,

from the great weight of the ends preventing the centre contracting regularly. He thinks your best plan would be to get one of the terra-cotta workers to make one, which he thinks he would do more cheaply than it could be sent from here; and their clay being finer, a much neater article could be made. It would be well to be on the spot, and see the rough clay put on the ends, as workmen in general have not much idea of what is required.

"To prevent the water filtering through the pots, mine were well glazed inside with flint-glaze, free from lead. Probably it would be better to glaze the outside, and leave the inside porous."

If a cylindrical form of vessel be preferred, it can be obtained without any material but glass in the construction; but there is a limit as to size. I procured from Mr. A. Pellatt's establishment a vase of the largest dimensions they would undertake to blow for me, viz. twelve inches in diameter. If attempted of greater size than this, the risk increases very rapidly, as they are liable to break in the manufacture, and also at any moment even after they have been some time in use. Mine, though not free, as I was warned, from the same danger, has hitherto survived nearly three years' service. The height may be chosen according to taste, as the risk does not depend on this, but on the diameter. Mine is ten inches high. I do not recommend this form; it is mean and inelegant; and as it is a blown vessel, the sides are not truly cylindrical.

Confectioners' show-glasses are very suitable for small specimens; they are usually about twice as high as broad, and are therefore more graceful. These afford peculiar facilities for the examination of their contents with a lens, as they can be easily

moved round, and may be placed before a candle or lamp for nocturnal investigations. They may be had of various sizes, from three to eight inches in diameter; six inches is a very convenient size. I have made very pretty vases for minute objects by taking the glass chimney of an Argand lamp, and fastening a well-fitted cork into one end for a bottom, on which I then poured black sealing-wax varnish until a smooth water-tight surface was formed. These are more convenient than wide-mouthed phials, as the sides are more truly perpendicular, and we avoid the unequal refraction produced by the thickened bottom of a phial.

A very pretty form of Aquarium is that of a bell-glass with cylindrical sides, which, being placed mouth upward, with the knobbed bottom set in a turned stand of varnished wood, possesses both stability and elegance. As the knob is not *fixed*, the vase may be turned round in its stand for observation. The hollow of the bottom is filled with sand and gravel up to the point where the sides become perpendicular, and on this floor is built the rock-work, &c. Such vessels, of various sizes and prices, are provided and fitted up by Mr. Lloyd, of St. John's Street Road.

For a conservatory, to which an Aquarium would form an appropriate accessory, a vase-like form might be given to a large tank. If the outline were octagonal, the objects in the interior would be visible through the plate-glass without the distortion caused by unequal refraction, which is a great objection to vessels with curvilinear sides. But in such a situation, the chief point of view would be from above the surface of the water; hence the depth should be comparatively small,

and the sides might recede, so as to increase the width upwards.

A good many animals, especially Anemones, Madrepores, Crabs and Annelides, may be kept in broad and shallow pans, in which the water does not exceed three or four inches in depth. The glass pans used for milk are good for this purpose. I have an earthenware pan with upright sides, about five inches deep, in which I have imitated the broken interior of a rock-pool, with irregular projections and promontories of cement. One advantage of such a vessel is that sea-weeds may almost be dispensed with, the extensive surface of water absorbing a large quantity of oxygen from the air. An oval foot-bath of whiteware makes a capital Aquarium.

COVERING.—Within an inhabited room, or wherever there is much liability to dust or soot, as there is necessarily everywhere in cities and large towns, the Aquarium may be protected by a cover. This may be made of fine muslin, or, which is better, of plate or sheet-glass, according to the dimensions required. The latter may simply be laid over the top of the vessel, allowing the escape of gases under the edge. It should be occasionally lifted for a moment, to allow of a change of the superincumbent air:—the necessity of this will be manifest, from the close smell which is perceived on lifting the cover, especially if there be many sea-weeds in the tank.

In ordinary circumstances, however, there is no necessity for a covering of any kind. My own tanks, though placed in an inhabited room, remain for months together uncovered, in winter and summer, without the least loss of transparency. The dust speedily sinks, and is harmless.

ASPECT.—The free access of light to the plants is indispensable, and therefore that situation is the best where the sun's rays fall most freely on their leaves. It is beautiful to see the thousands of tiny globules forming on every plant, and even all over the stones, where the infant vegetation is beginning to grow; to see these globules presently rising in rapid succession to the surface all over the vessel, and to see this process going on uninterruptedly as long as the rays of the sun are uninterrupted.

Now these globules consist of *pure oxygen*, eliminated by the vegetation under the stimulus of light; and as this is the vivifying principle of animal life, the importance of the process will be readily acknowledged. The difference between the profusion of oxygen-bubbles produced on a sunny day, and the paucity of those seen in a dark, cloudy day, or in a northern aspect, is very marked.

Yet there is one caution required. In summer the heat of the solar rays is very great, as well as their light; and if the vessel be small, and the volume of water very limited, it will become tepid in the mid-day sun, and the animals will be killed. Hence in a fierce summer day, it will be desirable to draw down the window-blind, or to interpose a curtain of muslin, oiled-paper, or ground glass, which will break the full power of the rays, without greatly interfering with their illumination.

COST.—On this point a hint or two, the record of my own experience, is all that I can give. If an Aquarium of considerable dimensions be required, one of unusual form, or much ornamented, regular professional estimates must be taken. But the following statements may be of use to some.

The tank which I have described as measuring 24 by 18 by 18 inches, cost me 3*l.* 10*s.*; the small one of the same form, 15 by 12 by 12 inches, was charged 21*s.* The sides of the former are of plate, those of the latter sheet-glass. These prices are barely more than the actual cost of manufacture. The cylindrical twelve-inch glass from Pellatt's cost 10*s.* 4*d.* Glass covers for these three tanks, cut to shape, were 10*s.* more. Show-glasses are sold by weight, and at the rate of 8*d.* or 9*d.* per lb., I think.

THE PREPARATION.

YOUR Aquarium being brought home, fixed in its intended situation, and properly seasoned, the next thing is to fit it up as a dwelling for its living inhabitants. Two or three points may be noticed here.

ARTIFICIAL ROCKS, CORALS, &c.—When the two longer sides only of the Tank are of glass, the two ends being made of slate, the latter should be veiled, by being made to imitate the irregular projections and ledges of rock, which may be done in a very picturesque manner. For this purpose, Roman, Portland, or other cement which hardens under water, should be employed; the slate must be faced with this, which while plastic may be fashioned into the semblance of rock. Pieces of branching corals may be set in it, if the effect of such accessories be thought desirable, and cavities may be formed here and there, into which the fragments of stone that support growing sea-weeds

may afterwards be dropped, so that the tufts may droop elegantly from the mimic cliff. A more elegant way of appropriating branching corals, is to make a broad foot of cement to them, plunging the base of the branch in it while soft; these, when the cement has hardened, will stand on the floor of the tank like trees, and imitate more perfectly the mode of growth of the arborescent madrepores.

Whenever cement is used, it will be absolutely necessary to allow it to remain in water for at least a month, in order to soak out the free lime, before it be introduced into the water which contains animals. The water in which it is soaked should be frequently changed, and as long as any prismatic scum appears on the surface, the cement is unfit for use. I have known a whole consignment of animals killed in one night from a neglect of this precaution.

THE BOTTOM.—As very many marine animals burrow, and as the observation of their proceedings is very interesting, they should be provided with the means of gratifying their inclinations. For this purpose a layer of sand should be put on the bottom of the tank, which may vary in depth from one to three inches. If sand from a sea-beach can be readily obtained, it is the most suitable; but the next best is coarse river-sand, such as the Thames sand commonly sold at the stone-wharves of London for building purposes. It should be well washed, until the water runs away clean: fresh water will do very well for this, but it must be drained off before the sand is put in. What is called silver-sand, and the common yellow earthy sand, sold in the shops for scouring, are not at all suitable, as they will tinge the water after any

amount of washing, the former with lime, the latter with ochre.

Small pebbles or fine gravel, likewise well washed, may be used to vary the bottom with the sand.

Masses of rock, of dimensions suitable to the Aquarium, should be put in to afford shelter and concealment to such animals as like the gloom. To afford this in the highest degree, a flat piece may be set, like a table, or *cromlech*, upon two or three upright blocks; or two tall pieces may lean against each other, forming a rude arch;—care being taken, whatever arrangement be chosen, that the masses stand with stability. It is of little consequence what sort of rock is selected,—limestone, sandstone, granite, conglomerate,—but the rougher, and the more full of cavities and angles, the blocks are, the better will be the effect.

WATER.—The purity of the water is of great importance. In London, sea-water may be easily obtained, by giving a trifling fee to the master or steward of any of the steamers that ply beyond the mouth of the Thames, charging him to dip it in the clear open sea, beyond the reach of rivers. I have been in the habit of having a twenty gallon cask filled for me, for which I give a couple of shillings.

The vessel in which it is conveyed requires attention. A cask is the best, if a considerable quantity of water is required; but it is absolutely indispensable either that it should be new, or at least that nothing injurious should have been previously contained in it, such as spirits, wine, chemicals, acids, &c.; since no soaking will prevent hurtful qualities from being communicated to the

water. Even the bungs ought to be new; I knew an instance in which a consignment of animals was lost, from no traceable cause, except that the water-cask, which was quite new, had been stopped with a bung, which had been previously used in a jar of some chemical solution; yet the bung had been, as was supposed, *thoroughly* soaked and cleansed. If a cask of fir-wood can be procured it is preferable: the wood of the oak, of which wine-casks are usually made, gives out *tannin* or *gallic acid*, to the contained water, which by its astringency converts the animal integuments into leather; if the water on coming out of the cask has a brown tinge, without interfering with its transparency, this is suspicious. If you cannot get any other than an oak cask, let it be well seasoned for two or three weeks before it be used, by filling it with water (fresh or salt), changed every day.

For smaller quantities of water large jars of stone-ware are the best, being free from every objection arising from liability to taint or tinge. Both casks and jars can be easily sent by railway to any part of the kingdom: and pure water will not spoil by delay.

ARTIFICIAL SEA-WATER.—In July 1854, I published the following communication in the "Annals and Magazine of Natural History."

"ON MANUFACTURED SEA-WATER FOR THE AQUARIUM.

"The inconvenience, delay and expense attendant upon the procuring of sea-water, from the coast or from the ocean, I had long ago felt to be a great difficulty in the way of a general adoption of the Marine Aquarium. Even in London it is

an awkward and precarious matter; how much more in inland towns and country places, where it must always prove not only a hindrance, but to the many an insuperable objection. The thought had occurred to me, that, as the constituents of sea-water are known, it might be practicable to manufacture it; since all that seemed necessary was to bring together the salts in proper proportion, and add pure water till the solution was of the proper specific gravity. . . .

"I took Schweitzer's analysis; but as I found that there was some slight difference between his and Laurent's, I concluded that a very minute accuracy was not indispensable. Schweitzer gives the following analysis of 1000 grains of sea-water taken off Brighton:—

Water	964·744
Chloride of sodium. . . .	27·059
Chloride of magnesium . .	3·666
Chloride of potassium. . .	0·765
Bromide of magnesium . .	0·029
Sulphate of magnesia . . .	2·295
Sulphate of lime.	1·407
Carbonate of lime	0·033
	999·998

"The bromide of magnesium and the carbonate of lime I thought I might neglect, from the minuteness of their quantities; as also because the former was not found at all by M. Laurent in the water of the Mediterranean; and the latter might be found in sufficient abundance in the fragments of shell, coral, and calcareous algæ, thrown in to make the bottom of the Aquarium. The sulphate of lime (plaster of Paris) also I ventured to eliminate, on account of its extreme insolubility, and

because M. Laurent finds it in excessively minute quantity. The compotent salts were then reduced to four, which I used in the following quantities:—

Common table salt	3½ ounces.	
Epsom salts	¼ „	
Chloride of magnesium . . .	200 grains	Troy.
Chloride of potassium	40 „	

To these salts, thrown into a jar, a little less than four quarts of water (New River) were added, so that the solution was of that density that a specific gravity bubble 1026 would just sink in it.

"The cost of the substances was—sulph. mag. 1*d.*; chloride mag. 3*d.*; chlor. pot. 1¼*d.*; salt, nil; —total, 5¼*d.* per gallon. Of course if a larger quantity were made the cost of the materials would be diminished, so that we may set down 5*d.* per gallon as the maximum cost of sea-water thus made.* The trouble is nothing, and no professional skill is requisite.

"My manufacture was made on the 21st of April, 1854. The following day I poured off about half of the quantity made (filtering it through a sponge in a glass funnel) into a confectioner's show-glass. I put in a bottom of small shore-pebbles, well washed in fresh water, and one or two fragments of stone with fronds of green sea-weed (*Ulva latissima*) growing thereon. I would not at once venture upon the admission of animals, as I wished the water to be first somewhat impregnated with the scattered spores of the *Ulva;* and I thought that if any subtle elements were thrown off from growing vegetables, the water should have the advantage of it, before the entrance of animal

* This was considerably over-rated: the cost is probably about 3½*d.* per gallon.

life. This, too, is the order of nature; plants first, then animals.

"A coating of the green spores was soon deposited on the sides of the glass, and bubbles of oxygen were copiously thrown off every day under the excitement of the sun's light. After a week, therefore, I ventured to put in animals as follows:—

2 *Actinia mesembryanthemum.*	*Coryne ramosa.*
7 *Serpula triquetra.*	*Crisia eburnea.*
3 *Balanus balanoides.*	—— *aculeata.*
2 *Sabella* ——— ?	*Cellepora pumicosa.*
2 *Sabellaria* (*alveolata* ?)	*Cellularia ciliata*
2 *Spio vulgaris.*	*Bowerbankia imbricata.*
1 *Cynthia* (*quadrangularis* ?)	*Pedicellina Belgica.*

"These throve and flourished from day to day, manifesting the highest health and vigour; the plants (including one or two Red Weeds that were introduced with the animals) looked well, and the water continued brilliantly crystalline. Within the succeeding month, specimens of *Actinia mesembryanthemum*, *A. anguicoma* and *A. clavata*, a *Trochus umbilicatus*, and a *Littorina littorea* were at different times added.

"Six weeks have now elapsed since the introduction of the animals. I have just carefully searched over the jar, as well as I could do it without disturbing the contents. I find every one of the species and specimens mentioned above, all in high health; with the exception of some of the Polyzoa, viz. *Crisia aculeata*, *Cellepora pumicosa*, *Cellularia ciliata*, and *Pedicellina Belgica*. These I cannot find, and I therefore conclude that they have died out; though, if I chose to disturb the stones and weeds, I might possibly detect them. These trifling defalcations do in nowise interfere

with the conclusion, that the experiment of manufacturing sea-water for the Aquarium has been perfectly successful.

"P. H. GOSSE.

"58, Huntingdon Street, Barnsbury Park,
June 9, 1854."

The small quantity of water thus experimented upon remains to this time (September 1855), having supported animal and vegetable life ever since without interruption, a period of seventeen months. It is as transparent as the day it was put in, rivalling the water of the clearest rock-pool, from which it can in no respect be distinguished, either in its sensible qualities, or in its fitness for plants and animals. Since that time I have made other and larger quantities, with the same success; so that I can confidently recommend the formula for general adoption. The salts are sold in packets, with all needful directions, by Mr. Bolton, a chymist in Holborn.

It is interesting to find that the more subtile constituents of sea-water, as *Lime*, *Iron*, *Silica*, and *Iodine*, which I neglect in my formula, are gradually communicated to the artificial composition by use. Dr. George Wilson, of Edinburgh, who has analyzed portions of each of my preparations, after several months' use, finds traces therein of all these substances, according to a Report on the subject, just read at the Glasgow Meeting of the British Association.

It is scarcely necessary to add, that, if you can conveniently procure water from the sea, you should do so by preference; "*si non, his utere mecum.*"

THE STOCK.

As I shall presently give some instructions concerning the modes of collecting both plants and animals, a few preliminary observations are all that will be needful here.

PLANTS.—What are the most suitable plants for an Aquarium? Not the Oar-weeds or Tangles (*Laminaria*); for though young specimens have an attractive appearance, they will not live long in captivity; they presently begin to decay, and slough off in slimy membranous shreds, filthy to look at, and hurtful to the living creatures. The *Fuci* live pretty well, but their sliminess and ugliness are fatal to their pretensions. From the Red and the Green orders we must make our selection.

Of the former these will be found good. *Rhytiphlæa pinastroides*, the *Polysiphoniæ*, *Corallina officinalis*, *Delesseria alata*, *Chondrus crispus*, *Phyllophora rubens* (this, especially when dredged from deep water, is one of the very best), the *Griffithsiæ*, and some of the *Callithamnia*.

Of the Green weeds *Codium tomentosum* does pretty well, and affords food for some Mollusca that will eat nothing else. The *Cladophoræ* are good; *Bryopsis plumosa*, a most elegant little plant, flourishes in confinement; but the *Enteromorphæ* and *Ulvæ* are probably the best of all sea-weeds for our purpose, and the most easily procured on every shore.

The pieces of rock to which the plants are attached should be as clean as possible. All adhering

Sponges, in particular, should be carefully scraped off, unless they are wanted for immediate examination; as they are almost sure to die, and corrupt the soil and water with sulphuretted hydrogen, a most nauseous and noxious gas, which turns everything black with which it comes into contact.

ANIMALS.—Of the animals which thrive best in an Aquarium (speaking, of course, only from my own limited experience and observation) the following may be mentioned:—

Fishes.—The smaller Sticklebacks; young specimens of the Grey Mullet, which have lived for more than three years in the Zoological Society's Aquarium; the Blennies and Gobies; the Spotted Gunnel; the smaller Wrasses; the Rocklings; the Flounder; the Dab; the Eels.

Mollusca.—The Sea-hare; the Periwinkle; the commoner Tops; the Purple; the Murex; the Chitons; the Bullas; the Scallops; the Mussel; the Modioles; the Anomia; the Oyster; and some of the sand-burrowing bivalves, as *Venus*, *Mactra*, *Pullastra*, &c. *Gastrochæna* and *Saxicava*, burrowers in stone, may be readily kept, and are very interesting, especially the former, which I have had in confinement for many months, in more than a single instance, and still possess.

Cirripedes.—The Acorn-barnacles (*Balanus* and *Chthamalus*), and the interesting little *Pyrgoma*, which is invariably found cemented to the plates of our larger Madrepore.

Crustacea.—The Strawberry Crab; the Swimming Crabs; the Shore Crab; the *Ebalia;* the Masked Crab; the Soldier Crabs; the Broad-clawed Crab; the Shrimps; the true Prawns; the *Athanas;* many of the *Entomostraca.*

Annelides. — The Gold-comb; the Sabellas; the Serpulas; the Sea Leech; the Long Worm; the Terebellas.

Zoophytes. — Many species of Sea Anemone, (except the Thick-horn, *Bunodes crassicornis*, which is precarious); both species of Madrepore.

The following are interesting, and may be preserved for a considerable time, but are rather more uncertain. Among FISHES, the Sea-scorpion (*Cottus*); the 15-spined Stickleback; the Butterfly Blenny; the Suckers; the Pipe-fishes. Among MOLLUSCA, all the Nudibranch, and most of the Tectibranch species; the *Naticæ*, the Cowry, the Whelk; the little *Rissoæ;* the *Phasianella;* the Cup-and-Saucer (*Calyptræa*); the lovely little *Acmea;* many Bivalves; the *Cynthiæ*, and *Ascidiæ*. Among CRUSTACEA, the *Pisæ;* the *Portuni;* small specimens of the Common Crab and Lobster; the *Hippolytes; Pandalus; Gammarus; Idotea.* Among ANNELIDES, the Sea Mouse; the Nereides; and the *Planariæ.* Of ECHINODERMS, the *Cribella*, *Palmipes*, *Asterina*, *Asterias*, *Echinus* and *Cucumaria.*

PROCURING SPECIMENS.—By far the most interesting mode of acquiring your stock, is the collection of them by your own personal research. But as this is not in every case practicable, we must have recourse to the labours of others. Mr. William Thompson at Weymouth, and Mr. James Heale at Ilfracombe, supply specimens from these localities; and, in London, Mr. W. A. Lloyd, 164, St. John Street Road, is a "Dealer in Living Marine Animals, Sea-weeds, Artificial Sea-water, and Marine and Fresh-water Aquaria." The last-named gentleman will undertake the whole labour

of supplying and stocking these interesting repositories of ocean life.

TRANSMISSION OF SPECIMENS.—Both plants and animals should be forwarded to their destination as soon after they are collected as possible; but, if they are detained, they may be kept in pans of sea-water, exposed to the light. The vessels, however, must be protected from heavy rains, as the admixture of a large quantity of fresh water would be fatal to both plants and animals. Should much rain have fallen on a vessel containing specimens, it should be carefully tilted, so as to allow the fresh water, which, from its less specific gravity, will be lying on the surface, to run off without mingling with the other. If this be well done, most of the collection, at least that portion of it which was nearest the bottom, may be preserved.

Living sea-weeds may be transmitted to long distances without water. I used to employ a tin box, enclosed by a basket. At the bottom I placed a layer of refuse weed, the common *Fucus serratus*, freshly gathered, and quite wet. On this bed I laid the growing specimens, arranging the pieces of rock so as not to shake about and injure the plants, until the box was nearly full; over all, refuse weed was again laid, filling up all hollows, and so pressing the whole when the box was shut, as to prevent any motion of the stones. The specimens arrived in the best condition, even the delicate *Delesseriæ* being uninjured.

Many animals may be forwarded in the same way. The Mollusca, many of the Echinodermata, several of the Crustacea, and all the Actiniæ are transmitted with more ease and less danger

thus than in water. A handful of loose weed, wet with sea-water, to keep a moist atmosphere around them, may be thrown into a canister or jar, and the animals placed in among it. The vessel should not be *filled*, nor should any pressure be allowed on the animals; the weed too, though fresh, must be plucked, as pieces of rock would be injurious to the more tender animals.

Fishes, however, many Crustacea, most of the Annelida, all Medusæ, and the more delicate Zoophytes, require to be sent in sea-water. I sometimes use wide-mouthed jars of stone-ware, with water-tight screwed tops, several of which may be packed in a hamper; at other times a large 12-gallon zinc pail, protected by a wicker case, with a screw lid, of which the central part is perforated with minute holes; at others, four small zinc cans, of square form, with perforate tops, fitted into an open box, like case-bottles in a wine-hamper. All of these modes answer well; I know not to which I should give the preference; except that for Fishes the large pail is decidedly the best. If heavy stones or oyster-shells, very rich in Zoophytes and Annelides, be required, a common cabbage-net may be suspended from the lid of the pail in mid-water; the stones or shells, being put into this net, will be kept from injuring themselves or their neighbours by banging about upon the bottom.

The more brief the period during which the specimens are *in transitu* the better. Hence they should be always forwarded *per mail train*, and either be received at the terminus by the owner, or else be directed "To be forwarded immediately by special messenger." The additional expense of this precaution is very small, and it may preserve

half the collection from death through long confinement.

The packages should be opened immediately on arrival; several bowls, pans, &c. should be ready, each half-filled with sea-water. The water in the vessels just received should be carefully dipped or poured off, and the specimens placed one by one in the bowls. Thus you will not only see which are alive and healthy, and which are sickly or dead; but the weeds, shells, &c. will be rinsed from the sediment, which has been abraded during the rattling of the specimens in travelling. The specimens can afterwards be deposited in the Aquarium, their permanent home.

Should any of the more delicate animals appear much exhausted, they may often be restored by a prompt aeration of the water around them. This is most readily effected by means of the Syringe, as I shall presently describe.

If you can so arrange matters, it will be a useful caution to allow your plants exclusive possession of the Tank for a week or two, not putting any animals in, until you see bubbles begin to form all over the sides, bottom, and rock-work, when the sun-light shines on them. This appearance will indicate a growth of incipient vegetation, which will greatly lessen the chance of death when the animals are introduced.

Finally, be moderate in your desire of dominion. Do not overcrowd your Tank. It is far better to have it but half occupied at first, and to add to its population from time to time, than, by a too eager desire to see it filled, make it a Black Hole of Calcutta, and mourn over a host of corpses, the wreck, perhaps, of a single night. Half-a-dozen

animals, averaging the bulk of a Periwinkle, or a moderate-sized Sea-anemone, to every gallon of water, are quite enough to begin with.

GENERAL DIRECTIONS.

The Aquarium is then established. The water, which at first is somewhat turbid, becomes in the course of a day or two clear and crystalline; the plants expand their feathery tufts in beauty, and the animals begin to take possession of their holes and corners, and to find themselves at home. But you must lay your account with the loss of some specimens; some will certainly die in the course of the first twenty-four hours, others in the first week. But those which survive the first ten days may be considered as pretty well established.

It is during this period that the grand trial of the experiment usually occurs. There is generally a large amount of animal matter attached to the sea-weeds, shells, and stones, which are received from the sea, such as minute Annelida, Mollusca, and Zoophytes: very many of these creatures are already dead, or die immediately; but being too minute to be detected and removed in detail, they decay, and presently contaminate the water. The first symptom of this is a slight dimming of the crystal translucency, which if unchecked soon increases to a milky whiteness, accompanied by a fetid odour, and terminates in the death of the whole animal collection.

PURIFICATION.—As soon as this begins to be perceived, the whole water should be drawn off by

means of a siphon, without disturbing the sediment, into pans, into which, for the present, the plants and animals may be put. The Tank should be wiped out and rinsed, and then the water should be filtered back into it. This is a very simple process: a funnel (if of glass, earthenware, or gutta-percha, the better) is placed over the tank, with a bit of sponge pushed lightly into the top of the tube, so as to allow the water to run through in a narrow, thread-like stream. Replace the plants and animals, reserving those pieces of rock, or those shells, that look suspicious, which may be kept in a bowl of water by themselves for a few days, till their state appears more fully.

This process of bringing every drop of the water into contact with the atmosphere, is an effectual remedy for destroying the tendency to putrefaction; as the animal fluids and solids held in suspension enter into combination with the oxygen of the air, and form the pure innocuous gas called *ozone*. The result will be that the milkiness will rapidly disappear; the water will assume a transparent clearness, which will in all probability be permanent; the plants will thrive, and the animals will be lively. This result will be rendered still more secure by filtering the water through pounded charcoal, and by allowing some pieces of the same substance to float in the tank.

Occasional Death.—It will still be needful to exercise a watchful supervision of the collection. It must be remembered that both the animals and plants are not in their natural circumstances, and that a certain amount of violence is done to their habits. Death, which spares them not at the bottom of the sea, will visit them in the Aquarium;

and hence the vessel should be occasionally looked over, *searched*, as it were, to see if there be any of the specimens dead. If the plants show an orange hue in patches, they must be taken up, and the diseased parts cut clean away. Dead animals must be at once removed, or contamination will soon result. The eye will soon recognise the individuals, and will miss the familiar forms; but you must not too hastily conclude that an animal, which you have been accustomed to see playing about, is dead, because you have not observed it for some days, and cannot find it. Probably it has secreted itself in some corner or crevice, whence it will emerge in a day or two. Still such a circumstance should excite your vigilance.

INSTRUMENTS.—For removing dead specimens or the like, a pewter spoon bent up to a right angle, with the shaft tied to a slender stick, is very useful. You can, if you please, make a more elegant affair of it. Two or three simple sticks or rods, some of them widened, spade-like, at the end, are also useful for pushing the specimens to any required point. And one or two small nets made by stretching a bit of lace or muslin over a ring of wire, fastened to a rod, will serve to catch and lift out such animals as you wish to transfer, for examination, or any other purpose, to another vessel. As a general rule, however, they should be disturbed as little as possible, and never handled.

ARTIFICIAL AERATION.—Although living and healthy plants will educe and throw off, under the influence of light, oxygen, in sufficient quantity to maintain in health a given number of animals, yet the artificial admixture of atmospheric air with the water may be employed as a valuable

auxiliary. I have used it with marked benefit; often having revived animals thereby, which, from the exhaustion of the water, were apparently in a dying state. Its utility as a means of maintaining the purity of the water is still more obvious; since it is by the frequent and successive presentation of the particles of water to the air, that the animal excretions, which they hold in suspension, become chemically changed, and deprived of their putrescent qualities. This is what takes place in nature. By the perpetual dashing of the waves against the shore, and especially against the ragged rocks, an immense quantity of air becomes entangled, in the form of minute bubbles, which by the various currents are diffused through the sea, and even carried to considerable depths, before they rise to the surface and become dissipated. Thus the violent agitation of the sea is a powerful agent in its purification.

One of the simplest modes by which this object can be effected, is the drip-glass. I have been accustomed to suspend over the Aquarium, a perforated bell-glass (I think it is called a bee-glass) of suitable size, into the orifice of which a bit of sponge may be pushed, or a cork drilled with small holes. The cord which suspends the drip-glass passes over a pulley at the top of the window, so as to be raised or lowered at pleasure. Every morning sufficient water from the Tank is drawn or dipped off, to fill the drip-glass, which is then hoisted to its full height. The contents run out in slender streams, or in a rapid succession of drops, which, passing through some four or five feet of air before they reach the Tank, become effectually purified.

A convenient mode of aeration is that effected

by strongly syringing the water. The instrument should be at least 1½ inch in diameter, and should be raised above the surface at every down-stroke. After a few moments' work, the whole Tank will be quite white with minute bubbles of air, resembling the sea when the waves dash and boil among the rocks.

The same purpose may be more efficiently accomplished at a slight expense, in a manner which would greatly augment the elegance of the Aquarium. In the engraving placed at the commencement of this treatise, I have represented a Fountain-Aquarium, a form of the invention particularly suitable for a conservatory or hall. It needs but a vessel fixed, as a reservoir, at some distance above the level of the Tank, in a higher story for example, whence a supplying tube may descend, and passing beneath the floor, ascend through the foot of the vase, to the surface of the water. All the visible portion may be easily concealed among the rock-work; while from the extremity a jet would play, proportioned in force to the weight of the supplying column, or, in other words, to the height of the reservoir above the surface. It would be needful to make the apparatus of some incorrodible material;—gutta percha, for instance, for the tube, with a nozzle of glass;—as metals would be acted on by the sea-water, and form noxious oxides. The water might either be carried up to the reservoir, or pumped up by an obvious extension of the apparatus.

Such a modification would doubtless be as efficient as it would be elegant. The constant, or at least frequent, dissemination of the water through the air would keep the whole volume in agreeable

coolness, as well as maintain its sparkling clearness and purity.

In a well-regulated Tank, however, none of these modes are necessary. My oldest reservoir, which has been in constant occupation for nineteen months, never has any artificial aeration, except an occasional syringing, and that is often intermitted for months together. The surface is now and then agitated with a stick, and broken by the addition of fresh water to supply the loss by evaporation, and this is all the external aid it receives. *Yet the water always maintains the most crystalline transparency and purity.*

EVAPORATION.—If the Tank remain habitually uncovered, or protected only by a coverlid of muslin, daily evaporation will soon reduce the volume of the water, and increase its specific gravity. The pure water alone rises in vapour, the various salts held in solution remaining the same in quantity, though the water should be reduced to half its original bulk. It is therefore needful that additions of pure *fresh* water (not *sea*-water) be made from time to time, to replace the loss by evaporation. Distilled water is of course the best, but, practically, river-water will answer perfectly well. The time and quantityof these additions ought to be regulated by a hygrometer, the specific gravity of the sea-water being maintained at about 1027, which is the average density of the waters of the Atlantic. A tolerable approximation to accuracy, however, may be made, by marking on the vessel the surface-level at first, and always maintaining the same level. A glass cover greatly prevents loss from evaporation, as will be manifest by the condensed moisture on it, especially after a cold night.

CLEANSING THE SIDES.—The sea-water constantly holds in suspension millions of the spores (or seeds) of Algæ, ready to adhere and grow as soon as they find a resting-place; and these are particularly abundant in the warm season. Whether those of the green kinds, the *Chlorosperms*, such as the *Ulva*, *Enteromorpha*, and various kinds of *Confervæ*, be more plentiful than others, or whether they are more easily satisfied with a place congenial to their growth, I know not; but these grow most obviously, in the proportion of a thousand to one. Before we have kept our tank stocked a fortnight, its transparent sides begin to be sensibly dimmed, and a green scurf is seen covering them from the bottom to the water's surface, which constantly accumulates, soon concealing the contents of the vessel from distinct observation. On examining this substance with a lens, we find it composed of myriads of tiny plants, mostly consisting of a single row of cells of a light green hue, forming minute threads which increase in length at the extremity; others display small irregularly puckered leaves of deeper green, which develop themselves into *Ulvæ*, or *Enteromorphæ*.

If we design the Aquarium to be of any service to us in the observation of its contents, this growth must be got rid of, or we might as well have a vessel with opaque sides. Here then we bring in the aid of the Periwinkle, which may be bought alive of any London fishmonger, half-a-pint for a penny. Exclusively a vegetable-eater, he delights in the green sea-weed, and nothing can be more congenial to his palate than these tender succulent growths. The little Yellow Winkle, so abundant on weedy rocks, possesses a similar appetite; but

he is less suitable for the service required, inasmuch as his constitution appears unable to bear constant submersion; his habit is to live a good deal exposed to the air, and even to the hot sun, and this seems essential to his health. I have found that if this little species be collected, pretty as the individuals are, they crawl around the sides for a day or two, as if seeking a more genial dwelling, and then one by one fall to the bottom and die. There is, however, another genus of Univalve Mollusca which may be made equally available with the Periwinkle, if indeed it be not superior for the purpose. I allude to those evenly conical shells, which belong to the genus *Trochus*, sometimes called from their form, Tops. Two species, *T. cinerarius* and *T. umbilicatus*, are scarcely less abundant on our weedy shores than the Periwinkles; the former of a dull purplish-grey, marked with close-set zigzag lines; the latter rather flatter, usually worn at the summit, of a dull olive or green, with narrow reddish bands radiating from the centre. Both are pearly in the interior, but the latter species is brilliantly iridescent.

These Tops and the common Periwinkle are very useful inhabitants of a marine tank; they make themselves at home, and feed readily. It is interesting to watch the business-like way in which they proceed. At very regular intervals, the proboscis, a tube with thick fleshy walls, is rapidly turned inside out to a certain extent, until a surface is brought into contact with the glass, having a silky lustre; this is the tongue; it is moved with a short sweep, and then the tubular proboscis infolds its walls again, the tongue disappearing, and every filament of conferva being carried up into the inte-

rior from the little area which had been swept. The next instant, the foot meanwhile having made a small advance, the proboscis unfolds again, the tongue makes another sweep, and again the whole is withdrawn; and this proceeds with great regularity. I can compare the action to nothing so well as to the manner in which the tongue of an ox licks up the grass of the field, or to the action of a mower cutting down swathe after swathe as he marches along. The latter comparison is more striking for the marks of progress which each operator leaves behind him. Though the confervoid plants are swept off by the tongue of the Mollusk, it is not done so cleanly but that a mark is left where they grew; and from its peculiar form and structure, the tongue leaves a series of successive curves all along the course which the Mollusk has followed, very closely like those which mark the individual swathes cut by the mower in his course through the field.

The unsightly appearance thus left must be got rid of by mechanical means. A stick with a bit of rag tied around its end, or, what is better still, a brush made on purpose, like a nail-brush with a very long handle proceeding from the side—a sort of hearth-brush in miniature, fitted with very close and stiff bristles—will rub off the greenness. It may be used about once in a month, or oftener in summer. On the stones of the bottom, the cement and rock-work, and even on that side of the tank which, being next to the window, is not used for observation, I would recommend that the green growth be not interfered with, but that the marine plants be allowed to grow undisturbed. A crop of self-sown weeds in the tank is far more valuable

than such as have been introduced on loose stones. And even from very early age the green growth is found to throw off a copious supply of oxygen bubbles. Care, too, must be taken not to molest or annoy the animals needlessly, as also to leave undisturbed any masses of spawn that may have been deposited on the glass.

TURBIDITY.—Occasionally the water in a tank, which has hitherto been quite translucent, becomes all on a sudden so turbid as completely to hide the contents from view, except such as are close to the glass. This turbidity may arise from either of two causes. If it is of a grey or whitish hue, forming clouds here and there, which disperse and form again elsewhere, the microscope will show that it is composed of an innumerable multitude of animalcules belonging to the Class INFUSORIA. Their presence is not an evil, but rather a means whereby an already existing evil may be remedied. Their sudden increase to such an extent as to be thus appreciable to the senses, is symptomatic of organic matters in the tank in a state of decomposition. If we allow a minute worm that has died to lie at the bottom of the tank, we shall see in a day or two, if we watch it with a powerful lens, that it is encompassed by a little cloud of moving atoms, which are the animalcules in question, and which are busily engaged in devouring not only the solid parts, but also the juices and invisibly minute particles that float off; and thus in a very short time they effectually dispose of the offensive substance. So, in the case of their increase to the extent just supposed, of producing a general turbidity, they will, if left to themselves, soon clear away the decomposing matter if it be not too great, and then

themselves gradually disappear, allowing the water to resume its original clearness. As soon, however, as we perceive such an appearance, we should carefully transfer the principal animals to another vessel, and search for the decomposing bodies, on the removal of which the water will presently be transparent and sweet as before.

But the opacity of the water may be dependent on a totally different cause. If it is of a green colour, rapidly deepening in intensity, it is vegetable in its origin, and arises from an infinite number of the spores (or seeds) of green *Algæ* dispersed through the fluid, and held in suspension there. Now, this appears to have no deleterious influence either on the plants or animals, which live and thrive as well as when the water is clear; but it is annoying because of its unsightliness, and because it effectually interferes with our observation of our cherished favourites. It is, too, a most inveterate evil; unlike the former, it is not self-curative, at least not certainly so, and it cannot be foreseen. I have had a large vessel that had been in full occupation for a year and a half,—during the whole of which time it had remained brilliantly colourless,—suddenly, without any imaginable cause, become green; and in the course of two days be so opaque that objects could not be discerned an inch from the sides.

The lens will not detect anything in the fluid in this case; it requires a very high power of the compound microscope to resolve the cause. With a magnifying power of 560 diameters, we see an immense number of oval atoms, apparently colourless (but, doubtless, having a very slight tinge of green visible only in the aggregate), and not more

than $\frac{1}{3000}$th of an inch in diameter. These I conceive to be the spores of a green *Oscillatoria*, or some kindred plant; for there is a tendency to the accumulation of the films of such plants in the vessels in which the phenomenon exists.

I know of no cure for this. Sometimes it will continue unchanged for many months, and then clear away as suddenly as it came. At others, it will diminish and promise a return of transparency, then suddenly return, and set in as dark as before. Future observation may throw light on the matter, but at present, so far as I know, it remains a difficulty.

Since the preceding paragraph was in type, however, Mr. W. A. Lloyd informs me that he has succeeded in overcoming this difficulty. By drawing off the green water, and putting it into a dark closet, he finds that in two or three weeks the turbidity quite disappears, the water resuming its pristine transparency. The explanation is doubtless as follows: light is necessary to the life of plants, or at least the green colouring principle in them cannot be developed without light; if, then, this be denied, the plants must wane and die. Now the opacity, as I have intimated, consists of the living germs of green plants; and these on being deprived of light gradually die away; after which the water is quite fit for use again. I am myself instituting experiments on the subject; and so far as I have proceeded, my results agree with those of Mr. Lloyd; so that I hope this problem is at length fairly solved.

Food.—I am continually asked, *how*, *with what*, and *how often* I feed my animals. My invariable reply is,—"Not at all." I do not find that they

need any supply but what they procure for themselves. In a well-stocked and established tank, the vegetable-feeders find a sufficient pabulum in the ever-growing weed; and all the carnivorous species are maintained in condition by the hosts of INFUSORIA and ENTOMOSTRACA that are always swarming. The lens shows these tiny creatures to be abundant in every collection of water that has been kept for a short time; and as they breed very fast, their increase is sufficient to meet the demands of their superiors in organization. At least, I find that my well-filled tanks need no other supply than this, and what the more predatory kinds occasionally obtain by the death of their fellows. For amusement, indeed, the Actiniæ, the Madrepores, the Prawns, and the Crabs, may be fed; and then the best diet is the lean of raw meat, cut into minute fragments; but it should be very sparingly done, and the rejected atoms carefully removed, lest putrefaction set in and spoil the whole.

INSTRUCTIONS FOR COLLECTING.

TIME.—What is commonly called *low-water*—that is, the time when the ebbing-tide recedes to the utmost point—is the period to be chosen for shore-collecting, as comparatively few marine animals or plants habitually live in situations where they are long exposed to the air and sun. But the lower the level, the more rich becomes the harvest; and hence the time of spring-tide is the most pro-

ductive, when the recess of the tide is the greatest. Spring-tides occur twice every month, viz. about the time of new and full moon; the very best tides of all are those of the second day after the change of the moon; but for two days before and two days after that, they recede very far; so that we may consider those weeks which commence two days before the change of moon and end five days after it, as good collecting periods, while the alternate weeks are nearly useless. The full-moon tides are generally greater than those of the new-moon; and those about the time of the equinoxes, or the spring-tides of March and April, and of September and October, are the best of the whole year. Prevailing winds, however, exercise some influence on the amount of recess of the tide.

The time of lowest water on any particular day can be readily ascertained from local tide-tables; and the young collector, in choosing the locality of his operations, will pay attention to this point beforehand, that he may select a place where the time of low-water on the days of spring-tides is the most convenient for his occupation. For instance, the time of low-tide on the day of full-moon is about noon on our western shores, but about six o'clock on the Sussex coast.

IMPLEMENTS.—I use a wicker-basket with a flat bottom and straight sides, divided into compartments. In two of these fit wide-mouthed jars, such, for example, as are used for preserves: if made of glass they are the better, as admitting a more ready examination of their contents; but jars of white-ware or stone-ware will do. The larger objects procured are put into these; and I commonly carry also a wide-mouthed phial, such as the

chemists keep *quinine* in, fitted into a third compartment, to receive the minuter and more delicate things. Then there is a fourth division running the whole length of the basket, in which lie a hammer and chisel, and which may receive large shells, crabs, &c. that do not require constant immersion. A geologist's *hammer* with a cutting edge, as well as a striking face, is the most useful; and the *chisel* must not be such as carpenters use, but one made wholly of iron, tipped with steel, such as is used by smiths, and technically called a *cold chisel.*

Sometimes, especially if the shore we are about to search be strewn with large stones or boulders, it will be well to secure the attendance of a man with a crowbar, to turn over the stones; as on their under surface, and beneath their shadow, valuable specimens are often found. With the same instrument, inserted into the fissures, great pieces of loose slaty rock may be wrenched off, which are very productive.

COLLECTING SEA-WEEDS.—Thus armed, we sally forth, choosing for our explorations a spot where low dark ledges of shelving rock run out into the sea, full of clefts and fissures half concealed by Bladder-weed and Tangle; or where the solid rock shoots up in irregular angular masses, scooped and hollowed into numberless little pools and basins, with dark, slimy caverns here and there, and rifts of shingly sand between. An unpractised foot would find the walking precarious and dangerous, for the rocks are rough and sharp, and the dense matting of black Bladder-weed with which they are covered, conceals many abrupt and deep clefts beneath its slimy drapery. These fissures, however, are valuable to us. We lift up the hang-

ing mass of olive-weed (*Fucus*) from the edge, and find the sides of the clefts often fringed with the most delicate and lovely forms of sea-weed; such, for example, as the winged Delesseria (*D. alata*) which grows in thin, much-cut leaves of the richest crimson hue, and the feathery Ptilota (*P. plumosa*) of a duller red. Beneath the shadow of the coarser weeds, as well as in open pools, delights also to grow the *Chondrus*, in the form of little leafy bushes, each leaf widening to a flattened tip. When viewed growing in its native element, this plant is particularly beautiful; for its numerous leaves glow with refulgent reflections of azure, resembling the colour of tempered steel. This weed when dried is useful for making jellies, and constitutes the Carrageen Moss of the shops.

We may observe among the sea-weeds many tufts of a small species, whose leaves are much and deeply cut, with the divisions rounded, and the general outline of the leaf pointed. Some specimens are of a dull purple, others of a rich yellow hue; and I refer to the species as an interesting example of the influence of light on the colour of marine plants. The yellow specimens are exposed to the sun's rays; the purple ones are such as have grown in deep shadow. The species is the *Laurencia pinnatifida* of botanists.

Turning from the hidden clefts, we explore the deep pools that lie between the ledges. High wading-boots are necessary for this purpose, as we have to work in the water. The great Oar-weeds and Tangles (*Laminaria*) are growing here, large olive sea-weeds that wave to and fro with the undulations of the sea; the former a long narrow puckered frond of brown colour; the latter, a broad

smooth leathery expanse of deeper colour on a slender stalk, splitting with age into a number of lengthened fingers or ribbons, and hence called the Fingered Tangle (*Laminaria digitata*). Among these grow clusters of an elegantly frilled species, of delicate thin texture, and yellow-brown hue, bearing no slight resemblance to the tresses of some fair lady: this also is a *Laminaria*, but I am not quite sure whether it is the young state of the former species, or entitled to a name of its own. In the latter case, it is the *L. phyllitis* of botanists.

In these deep pools grow also many bunches of broad dark-red leaves, generally about as large as one's hand, smooth and glossy, of a dark crimson hue, but apt to run off into a pale greenish tint towards the tips; their edges have often little leaves growing on them. It is the Dulse or Dillis (*Rhodymenia palmata*), which is eaten by the poor of our northern shores as a luxury.

This is a showy plant, very beautiful when its tufts of large deep-red fronds are seen in the sea, where the perpetual wash of the waves keeps their surface clean and glossy, but not very suitable for an Aquarium. Its leaves soon decay; spots of orange-colour begin speedily to appear, which increase fast, and, uniting into large patches, slough off in slimy shreds. The appearance of an orange-colour, on crimson or purple weeds, is always a sign of the death of that part, and is the infallible precursor of decay. As soon as it appears, or at least if it begins to increase, the specimen should be ejected without mercy; as the diffusion of the gases from decaying vegetable matter is speedily fatal to most animals.

In deep pools, and narrow clefts near the verge

of lowest water, where the overshadowing rock excludes the sun's rays and imparts a genial obscurity, grow several of our most delicate and beautiful *Algæ*. Foremost among them is the Oak-leaved Delesseria (*D. sanguinea*), with tufts of crimson leaves, exquisitely thin, much puckered at the edge, and strongly nerved. The *Iridæa*, whose leaves are smooth and leathery, and of a dark brownish scarlet, is often the companion of the former. Here, too, we find the *Phyllophora*, another weed of brilliant red hue, with unnerved leaves much divided, giving origin to other leaves, and these again to others. It is usually much covered with the cells and shrubs of various species of *Polyzoa*, exquisitely beautiful objects for the microscope. The *Gelidium corneum* is another fine red weed, commonly of small size and slender, but prettily fringed with processes all round the edges of the leaves. This and the preceding are very hardy in confinement, and form very suitable plants for an Aquarium.

When we can no longer work at so low a level, we recede to the slopes of the ledges yet uncovered, and find other species in the quiet sheltered pools. A weed is found here, growing in dense mossy patches on the perpendicular and overshadowed edges of the rock, which, when examined, looks like a multitude of tiny oval bladders of red-wine, set end to end in chains. This pretty sea-weed is called *Chylocladia articulata*.

Here also grows the stony Coralline, a plant bearing some resemblance to that just named, in the peculiar jointed form of its growth. Low-lying pools are often incrusted with a coat of stony or shelly substance of a dull purple hue, having an appearance closely like that of some lichens; the

crust investing the surface of the rock, and adhering firmly to it, in irregular patches, which continually increase from the circumference, in concentric zones. This is the young state of the *Corallina officinalis*, which by and by shoots up into little bushes of many jointed twigs, diverging on every hand, or hanging in tufts over the edges of the rock-pools. Young collectors are eager, I perceive, to seize such specimens as are purely white; but this condition is that of death; in life and health, the shoots are of the same pale purple hue as the lichenous crust. This plant in both states (for plant it undoubtedly is, though principally composed of lime, and of stone-like hardness) is suitable for a tank, as it survives and flourishes long; and your pieces of rock-work you may select from such places as are covered with the purple crust.

The most valuable plant of all for our purpose is the Sea Lettuce (*Ulva latissima*). Every one is familiar with its broad leaves of the most brilliant green, as thin as silver-paper, all puckered and folded at the edge, and generally torn and fretted into holes. It is abundant in the hollows of the rocks between tide-marks, extending and thriving even almost to the level of high water, and bearing with impunity the burning rays of the summer's sun, provided it be actually covered with a stratum of water, even though this be quite tepid. It therefore is more tolerant than usual of the limited space and profuse light of an Aquarium, where it will grow prosperously for years, giving out abundantly its bubbles of oxygen gas all day long. It is readily found; but owing to the excessive slenderness of its attachment to the rock, and its great fragility, it is not one of the easiest to be obtained

in an available state. The grass-like *Enteromorphæ* have the same qualities and habits, but their length and narrowness make them less elegant. The *Cladophoræ*, however, are desirable; they are plants of very simple structure, consisting of jointed threads, which grow in dense brushes or tufts of various tints of green. Some of them are very brilliant; the commonest kind is *C. rupestris*, which is of a dark bluish-green; it is abundant in most localities.

These are a few of the sorts of sea-plants which are met with in the situations I have described. In order to transfer them to an Aquarium, a portion of the rock on which they are growing must be removed. These plants have no proper roots, and therefore cannot be dug up and replanted like an orchis or a violet, but adhere by a minute disk to the surface of the rock, and, if forcibly detached, die. I therefore bring the hammer and chisel into requisition, and split off a considerable fragment of the solid stone, which then, with the plant adhering to it, is placed in the Aquarium. This is often a difficult, always a delicate, operation; the rock is frequently so hard as to resist the action of the chisel, or breaks at the wrong place; sometimes, on the other hand, it is so soft and friable as to crumble away under the implement, leaving only the isolated plant deprived of its attachment; and sometimes, at the first blow, the sea-weed flies off with the vibration of the shock. Often we have to work under water, where the force of the blows is almost rendered powerless by the density of the medium, and where it is next to impossible to see with sufficient clearness to direct the assault.

As the plants are detached, they are placed one

by one in security. The finer and more delicate ones, as the *Delesseria* for instance, are immediately dropped into a jar of water; for only a few minutes' exposure of their lovely crimson fronds to the air would turn them to that dull orange colour already mentioned as the sign of incipient decay. The hardier sorts are laid in the basket,—a layer of damp refuse-weed being first put in to receive them,—and covered lightly with damp weed. The degree of moisture thus secured is sufficient to preserve many species from injury for hours.

COLLECTING ANIMALS.—I have been speaking of the haunts of the living *Algæ*, and of the manner of procuring them; because in sequence of idea these come first into consideration. But in point of fact, the search for animals goes on simultaneously with the process just described; the same haunts which are affected by the marine plants concealing various animals.

Close examination of the fissures of the pools, of the rough and corroded stones that have been fished up, and even of the sea-plants themselves, reveals many curious creatures of various kinds and forms, each of which, when found, is seized and consigned to one or other of the jars. The plants often bear the more delicate Zoophytes, as *Coryne*, *Sertularia*, *Campanularia*, &c. growing parasitically upon them; and some interesting Sponges, as *Grantia compressa* and *G. ciliata*. But more generally the Sponges are found incrusting the surface of the rocks in the darkest places, especially on the sides of caverns, intermixed with many species of the Polyzoa.

The Sea-anemones (*Actinia*, &c.) adhere to rocks; the common Smooth species (*A. mesembryanthemum*) often high up, exposed to the air; but

the rarer kinds generally in the sheltered crannies and basins, in gravelly fissures, or on the under surface of stones. They must be carefully dislodged by inserting the finger-nail beneath the base, and gradually shoving them off; but those sorts that live in holes must be chiselled out.

Many of the Star-fishes, Sea-urchins, and Sea-cucumbers are to be procured by turning over loose stones at the lowest tide-level; various species of Annelides haunt the same places, and some of these are of surpassing beauty. Many curious kinds of Crabs and other Crustacea, too, and in spring the elegant Nudibranch Mollusca, reward the labour of stone-turning.

The Univalve Mollusca crawl freely over the surface of the rocks, or roam amid the umbrageous foliage of the weeds that fringe the clear pools; whither also many of the lithe and slender worms, and the swimming Crustacea, as the Prawns and their allies, resort. Some of the Bivalve Mollusca burrow into the solid rock itself, and the Acorn Barnacles are seated by thousands on its surface. Many of the Bivalves, however, are to be dug out of the sand or mud of the flat shore, and many interesting animals are found on the beds of sea-grass (*Zostera*) that grow on such a coast. These are collected by means of a keer-drag, a form of net which the reader may find described, with its use, in my "Aquarium," p. 56.

DREDGING.—To the same work I must refer for a description of dredging and its prolific results, whereby the bottom of the deep sea is scraped and the varied contents brought to light. Multitudes of animals of the highest interest are procured by dredging, that the shore-collector would never find;

and yet shore-collecting must always be the main resource, at least of the majority.

TOWING.—One more means of obtaining animals remains to be mentioned,—the surface-net. This may be made of stout muslin, in the form of a bag, two feet deep, sewed on a thick brass ring a foot in diameter, which is screwed at the end of a staff six feet long. The staff should be of tough wood, such as hickory or lance-wood. The net is held at the surface of the sea, the collector sitting in a boat rowed gently along. The afternoon and evening of a calm sunny day are most productive, especially in the latter part of summer and autumn, when the lovely *Medusæ*, the little *Beroe*, and many forms of freely swimming ANNELIDA and CRUSTACEA occur in abundance. At frequent intervals, the bag of the net must be reversed and plunged into a glass jar of clear water, when the captives will float off into the vessel.

For many details of this and other modes of collecting, and of the history of the curious creatures obtained thereby, I beg once more to refer to my "Devonshire Coast," and "Aquarium," which are expressly devoted to these subjects.

THE END.

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